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(54) **SYSTEMS AND METHODS FOR ENGINE FUEL CONTROL**

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G01M 15/00 (2006.01)

(52) **U.S. Cl.** **73/114.62**

(58) **Field of Classification Search** 73/114.58, 73/114.62; 123/406.13
See application file for complete search history.

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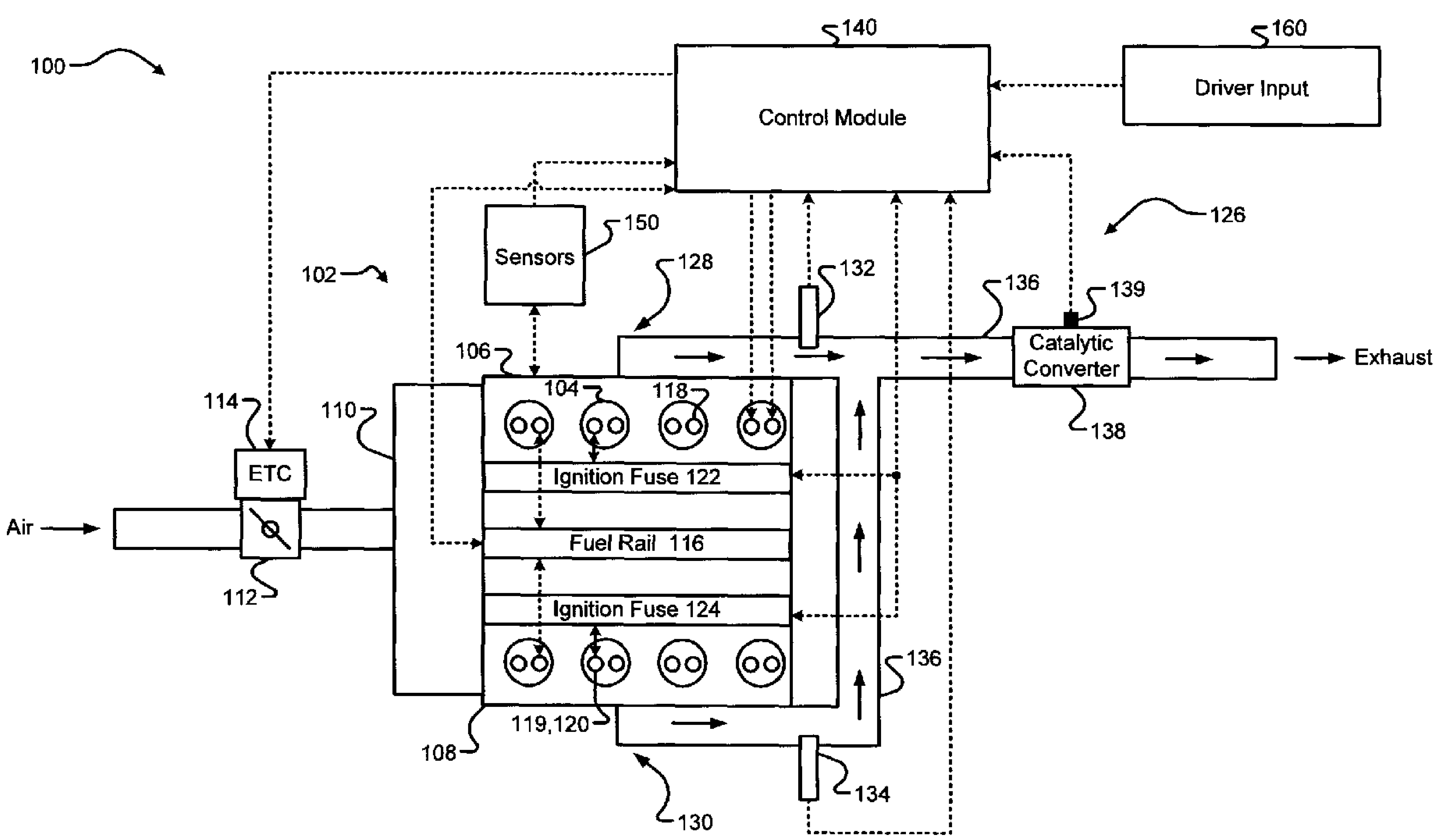
Primary Examiner — Freddie Kirkland, III

(57) **ABSTRACT**

An engine system includes a status determination module and an open-loop fuel control module. The status determination module determines whether a first ignition fuse is in a failure state. The open-loop fuel control module disables a first plurality of fuel injectors and actuates a second plurality of fuel injectors based on a first air/fuel (A/F) ratio when the first ignition fuse is in the failure state, wherein the first ignition fuse and the first plurality of fuel injectors correspond to a first cylinder bank, and wherein a second ignition fuse and the second plurality of fuel injectors correspond to a second cylinder bank.

18 Claims, 4 Drawing Sheets



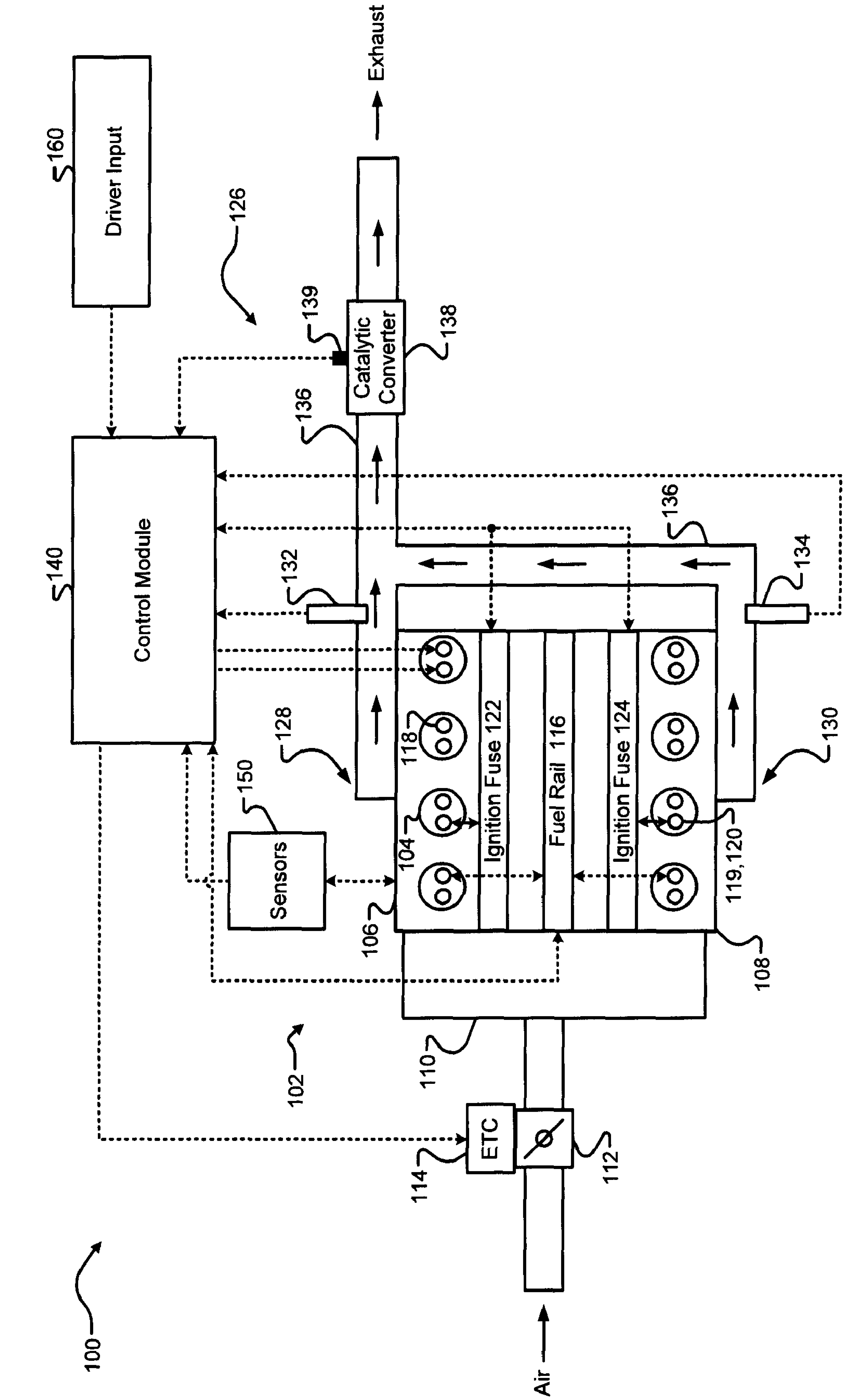

Exhaust
Driver Input
160
126
139
Catalytic Converter
138
136
Control Module
140
136
132
134
128
118
Ignition Fuse 122
Fuel Rail 116
Ignition Fuse 124
130
150
Sensors
104
119,120
106
108
110
102
ETC
114
112
100
Air

FIG. 1

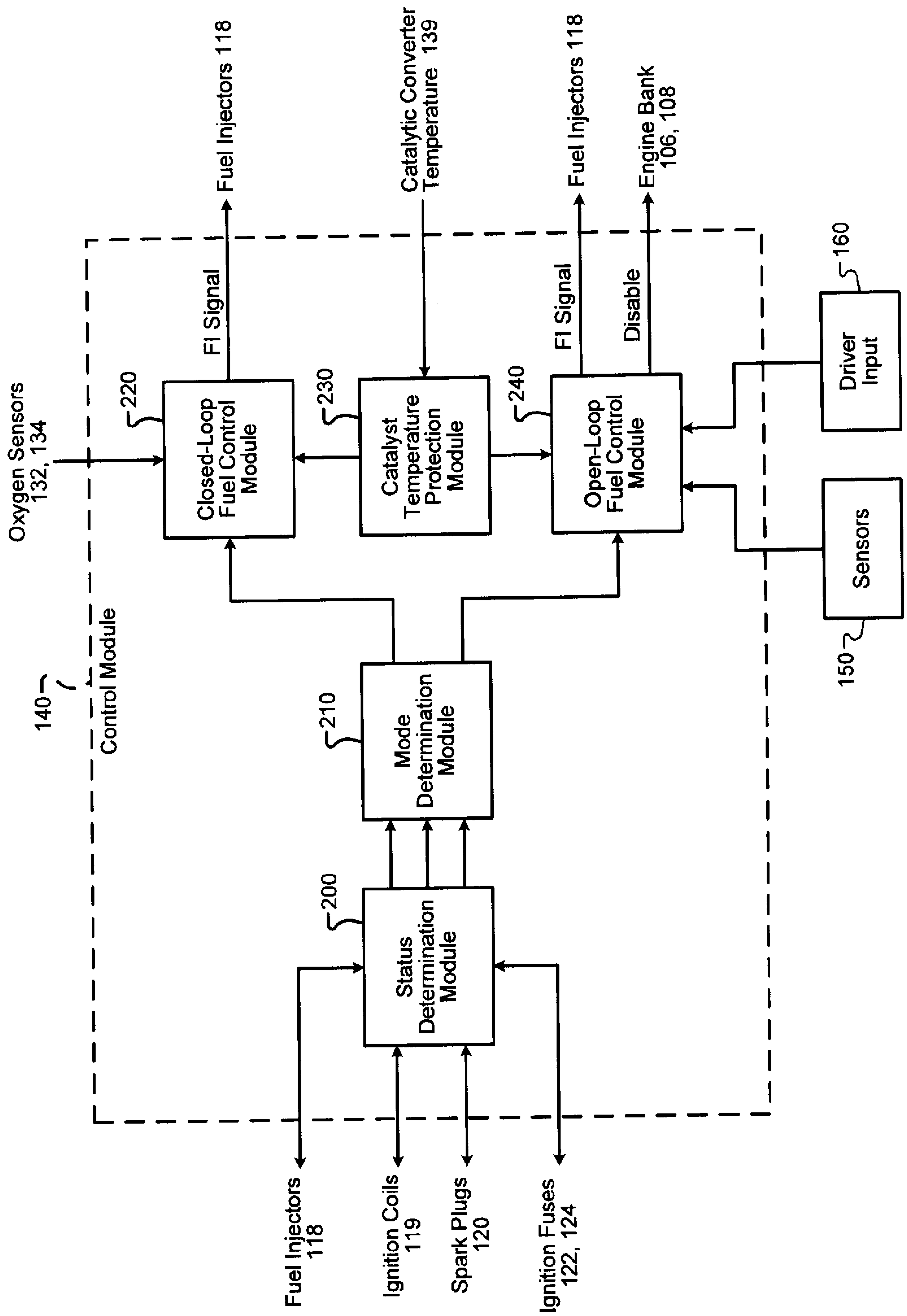
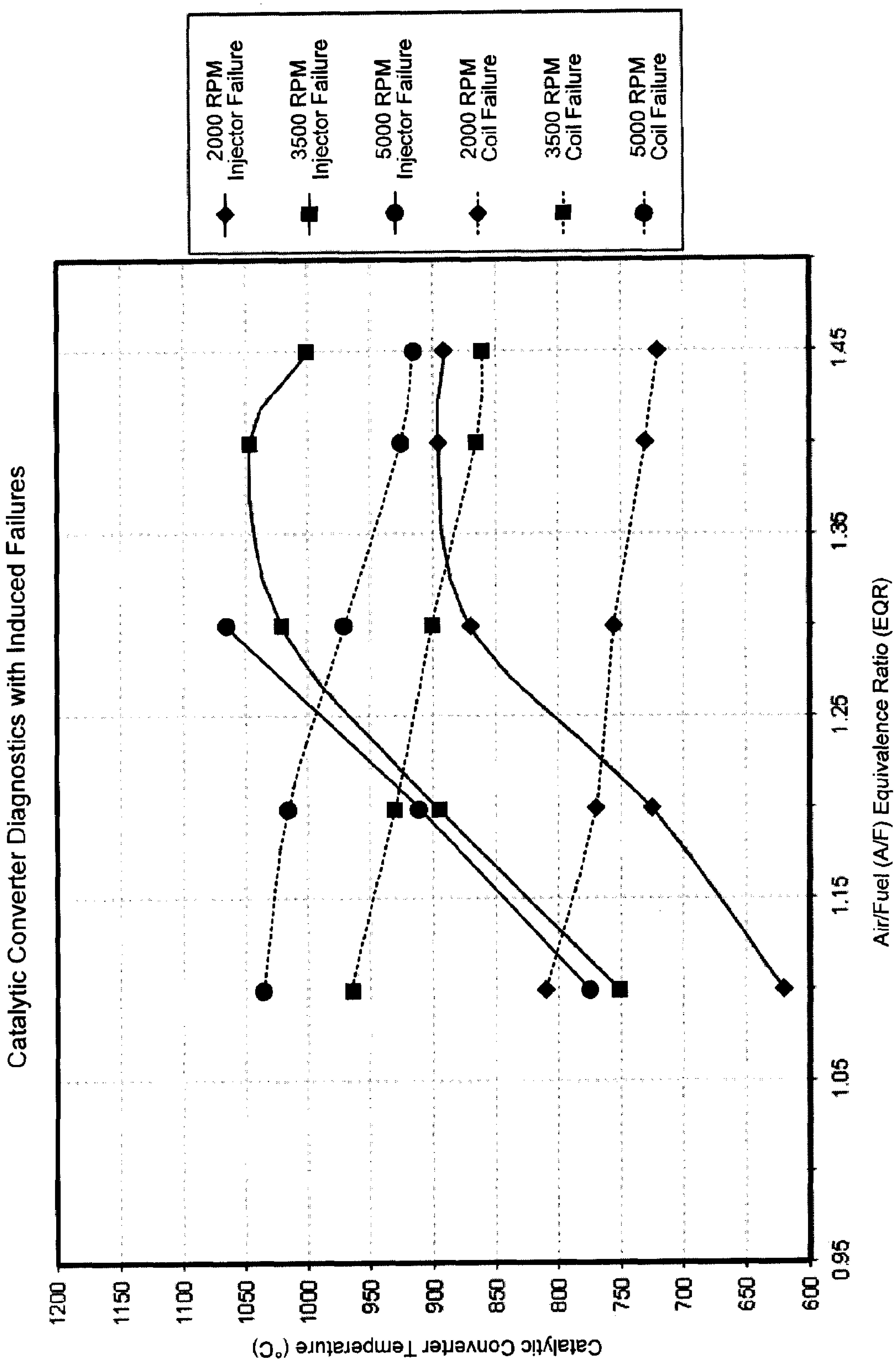

Fuel Injectors 118
Catalytic Converter Temperature 139
Fuel Injectors 118
Engine Bank 106, 108
Oxygen Sensors 132, 134
FI Signal
FI Signal
Disable
220
Closed-Loop Fuel Control Module
230
Catalyst Temperature Protection Module
240
Open-Loop Fuel Control Module
160
Driver Input
150
Sensors
140
Control Module
210
Mode Determination Module
200
Status Determination Module
Fuel Injectors 118
Ignition Coils 119
Spark Plugs 120
Ignition Fuses 122, 124

FIG. 2



Catalytic Converter Diagnostics with Induced Failures
Catalytic Converter Temperature (°C)
1200
1150
1100
1050
1000
950
900
850
800
750
700
650
600
0.95
1.05
1.15
1.25
1.35
1.45
Air/Fuel (A/F) Equivalence Ratio (EQR)
2000 RPM Injector Failure
3500 RPM Injector Failure
5000 RPM Injector Failure
2000 RPM Coil Failure
3500 RPM Coil Failure
5000 RPM Coil Failure

FIG. 3

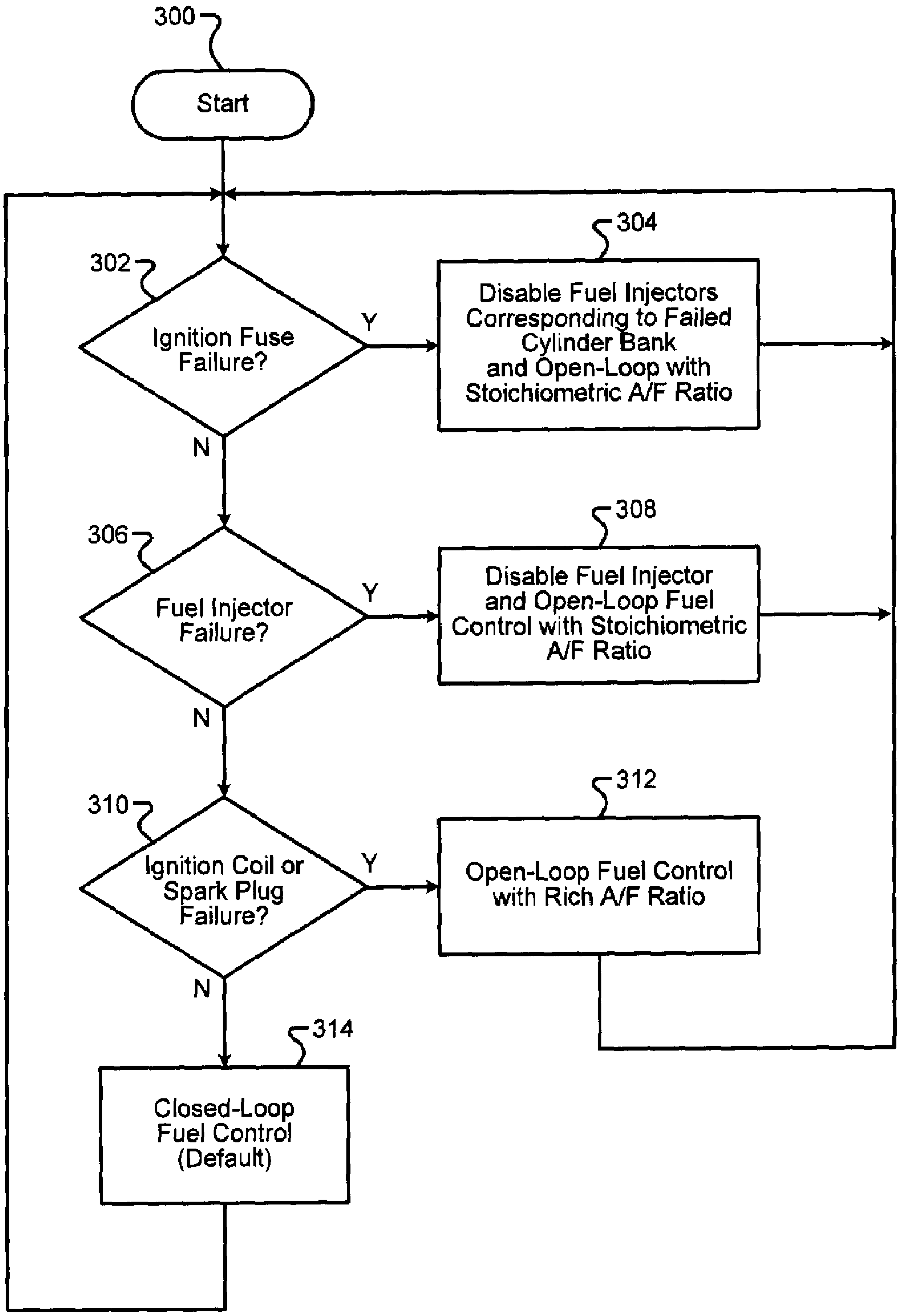

300
Start
302
Ignition Fuse Failure?
Y
304
Disable Fuel Injectors Corresponding to Failed Cylinder Bank and Open-Loop with Stoichiometric A/F Ratio
N
306
Fuel Injector Failure?
Y
308
Disable Fuel Injector and Open-Loop Fuel Control with Stoichiometric A/F Ratio
N
310
Ignition Coil or Spark Plug Failure?
Y
312
Open-Loop Fuel Control with Rich A/F Ratio
N
314
Closed-Loop Fuel Control (Default)

FIG. 4

SYSTEMS AND METHODS FOR ENGINE FUEL CONTROL

FIELD

The present disclosure relates to internal combustion engines and more particularly to fuel control systems in multiple bank engine systems.

BACKGROUND

The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

Air is drawn into an engine through a throttle and distributed to a plurality of cylinders through an intake manifold of an intake system. Fuel is mixed with the intake air to create an air/fuel (A/F) mixture. The A/F mixture is combusted within cylinders of the engine to generate drive torque. More specifically, combustion reciprocally drives pistons that rotate a crankshaft to provide torque output from the engine.

Fuel is delivered to the cylinders by a fuel system that may include a fuel rail and a plurality of fuel injectors. Combustion within the cylinders is controlled by an ignition system that may include a plurality of ignition coils and a plurality of spark plugs. Exhaust gases are expelled from the cylinders and out of the engine through an exhaust system that may include an exhaust manifold and a catalytic converter.

The engine may include one or more banks of cylinders. An engine with one bank may be referred to as an inline engine because of the straight orientation of its cylinders. In an inline engine, each piston may be attached to a different crankpin on the crankshaft. Each of the plurality of cylinders may include a fuel injector that supplies the cylinder with fuel from a common fuel rail. Additionally, each of the plurality of cylinders may include a spark plug that supplies the cylinder with spark, and an ignition coil that supplies the spark plug with voltage.

An engine with two banks may be referred to as a V-type engine because of the angled orientation of its cylinders. The two banks may be aligned at an acute angle (i.e. less than 90°). For example, a V-6 engine may include two banks of three cylinders each. In a V-type engine, one piston from each cylinder bank may be attached to each crankpin on the crankshaft. In other words, two pistons may be attached to each crankpin.

A V-type engine is typically smaller than an inline engine of similar displacement. However, in V-type engines each ignition coil in the cylinder bank may share a common ignition fuse that is different from one or more fuses associated with the fuel injectors in the cylinder bank. Therefore, when the ignition fuse of a cylinder bank fails, the corresponding fuel injectors (operating on a different fuse) may continue injecting fuel. The injecting of fuel into cylinders that include inoperable ignition coils due to the failed ignition fuse may result in decreased performance, increased emissions, and/or damage to engine system components such as the catalytic converter.

SUMMARY

An engine system includes a status determination module and an open-loop fuel control module. The status determination module determines whether a first ignition fuse is in a failure state. The open-loop fuel control module disables a first plurality of fuel injectors and actuates a second plurality of fuel injectors based on a first air/fuel (A/F) ratio when the first ignition fuse is in the failure state, wherein the first ignition fuse and the first plurality of fuel injectors correspond to a first cylinder bank, and wherein a second ignition fuse and the second plurality of fuel injectors correspond to a second cylinder bank.

A method includes determining whether a first ignition fuse is in a failure state, and disabling a first plurality of fuel injectors and actuating a second plurality of fuel injectors based on a first air/fuel (A/F) ratio when the first ignition fuse is in the failure state, wherein the first ignition fuse and the first plurality of fuel injectors correspond to a first cylinder bank, and wherein a second ignition fuse and the second plurality of fuel injectors correspond to a second cylinder bank.

Further areas of applicability of the present disclosure will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure will become more fully understood from the detailed description and the accompanying drawings, wherein:

FIG. **1** is a functional block diagram of an engine system according to the present disclosure;

FIG. **2** a functional block diagram of a control module according to the present disclosure;

FIG. **3** is a graph illustrating the relationship between air-to-fuel (A/F) ratio and catalytic converter temperature during fuel injector and ignition coil failures; and

FIG. **4** is a flow diagram illustrating steps performed by the control module according to the present disclosure.

DETAILED DESCRIPTION

The following description is merely exemplary in nature and is in no way intended to limit the disclosure, its application, or uses. For purposes of clarity, the same reference numbers will be used in the drawings to identify similar elements. As used herein, the phrase at least one of A, B, and C should be construed to mean a logical (A or B or C), using a non-exclusive logical or. It should be understood that steps within a method may be executed in different order without altering the principles of the present disclosure.

As used herein, the term module refers to an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group) and memory that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable components that provide the described functionality.

Referring now to FIG. **1**, an engine system **100** is shown. The engine system **100** includes a direct fuel injection engine **102**. For example, the engine **102** may be a spark-ignition, direct-injection (SIDI) engine. A plurality of cylinders **104** of the engine **102** may be configured in a V-type configuration. For example, the engine **102** may include eight cylinders **104** as shown, although the engine **102** may include a greater or lesser number of cylinders **104**. The cylinders **104** of the engine **102** are depicted as being arranged in two cylinder banks **106**, **108**.

Air is drawn into the engine **102** through an intake manifold **110** and a throttle valve **112**. The throttle valve **112** is actuated to control airflow into the engine **102**. For example, an electronic throttle controller (ETC) **114** may control the throttle valve **112** and, therefore, airflow into the engine **102**.

A fuel rail **116** supplies the cylinders **104** with fuel from a fuel tank (not shown) that mixes with the air to form the air and fuel (A/F) mixture. While one fuel rail **116** is shown, the engine system **102** may include one fuel rail for each engine bank **106**, **108**. A plurality of fuel injectors **118** supplies the cylinders **104** with fuel from the fuel rail **116**.

The A/F mixture is combusted within the cylinders **104** of the engine **102**. Combustion may be initiated by a plurality of ignition coils **119** and a plurality of spark plugs **120**. In other words, voltage may be supplied to each spark plug **120** by a corresponding ignition coil **119**. More specifically, each ignition coil **119** may receive a voltage (e.g. 12V) from a battery (not shown) and transform the voltage into a higher voltage required to spark a corresponding spark plug **120**. Furthermore, ignition fuses **122**, **124** may be connected in series with the battery (not shown) and each of the ignition coils **119**. More specifically, each of the ignition fuses **122**, **124** may correspond to one of the banks of cylinders **106**, **108**, and thus each of the ignition fuses **122**, **124** may correspond to half of the cylinders **104** and half of the corresponding ignition coils **119**.

Exhaust gas resulting from combustion of the A/F mixture is expelled from the engine **102** to an exhaust system **126**. More specifically, exhaust expelled from each of the cylinders **104** of cylinder bank **106** converges at confluence point **128**. Similarly, exhaust gas expelled from each of the cylinders **104** of cylinder bank **108** converges at confluence point **130**.

The cylinder banks **106**, **108** each have an associated oxygen sensor that measures oxygen concentration of the exhaust gas produced by the cylinders **104** of that cylinder bank. For example, oxygen sensor **132** may be associated with cylinder bank **106** and oxygen sensor **134** may be associated with cylinder bank **108**. The oxygen sensors **132**, **134** output signals corresponding to oxygen in the exhaust produced by the cylinders **104** of the cylinder banks **106**, **108**, respectively.

Oxygen sensor **132** may be located at any suitable location, such as at or downstream of confluence point **128**. Similarly, oxygen sensor **134** may also be located at any suitable location, such as at or downstream of confluence point **130**. The oxygen sensors **132** and **134** may be any suitable type of oxygen sensor, such as wide-band type oxygen sensors. The signals output by the oxygen sensors **132** and **134** may be any suitable type of signal, such as analog voltage signals.

The exhaust gas flows past the oxygen sensors **132**, **134** and the exhaust may be brought together by a system of exhaust pipes **136**, which carry the exhaust to a catalytic converter **138**. While a Y-type exhaust system **126** is shown, it can be appreciated that other exhaust system configurations may be implemented. For example, a dual exhaust system may be implemented such that the exhaust is not brought together by the system of exhaust pipes **136**. In other words, in a V-type engine, each cylinder bank may have one independent exhaust pipe and one independent catalytic converter. Thus, for example, cylinder bank **106** may have an exhaust pipe and catalytic converter and cylinder bank **108** may have a different exhaust pipe and a different catalytic converter. For example, the two separate sets of exhaust pipes may be in parallel to each other.

The catalytic converter **138** selectively reacts with various components of the exhaust before the exhaust is expelled from the exhaust system **126**. The oxygen sensors **132**, **134** are located upstream of the catalytic converter **138**. In one embodiment, a catalyst temperature sensor **139** measures a temperature of the catalyst in the catalytic converter **138** and communicates the catalyst temperature (T_{CAT}) to a control module **140**. Alternatively, the catalyst temperature T_{CAT} may be modeled by the control module **140** based on other parameters.

The control module **140** controls operation of the engine system **100**, and more specifically torque output of the engine **102**. The control module **140** may control the torque output of the engine **102** based on input from sensors **150**. The sensors **150** generate signals based on operating conditions of the engine, such as engine temperature and engine speed (i.e. crankshaft revolutions per minute, or RPM). The control module **140** may also control torque output of the engine **102** based on driver input **160**, such as position of an accelerator pedal.

The control module **140** may control torque output by controlling the A/F mixture. More specifically, the control module **140** may control air, fuel, and/or spark provided to each of the cylinders **104**. For example, the control module **140** may control air with the throttle valve **112**, fuel with the fuel rail **116** and the fuel injectors **118**, and/or spark with the ignition coils **119** and the spark plugs **120**. In one embodiment, the control module **140** may control the A/F mixture to achieve a stoichiometric A/F mixture (i.e. 14.7:1). The control module **140** may also control the A/F mixture in response to inputs received from the sensors **150** and/or the driver input **160**. For example, when driver input **160** corresponds to torque above a predetermined threshold, the control module **140** may richen the A/F mixture. In other words, the control module **140** may include a plurality of A/F ratios. For example, the plurality of A/F ratios may include an A/F ratio for efficiency and an A/F ratio for power.

In one embodiment, the control module **140** may control the A/F mixture in one of three modes: closed-loop fuel control (i.e. default) mode, catalytic temperature protection mode, and open-loop fuel control mode. Closed-loop fuel control mode includes controlling fuel injection based on feedback from the oxygen sensors **132**, **134**. Open-loop fuel control mode includes controlling fuel injection without feedback. For example, open-loop fuel control mode may include controlling fuel injection based on one of a plurality of A/F ratios. Catalytic temperature protection mode includes controlling fuel injection to control temperature of the catalytic converter **138**. For example, catalytic temperature protection mode may include decreasing the A/F ratio (enriching the A/F mixture) when the temperature of the catalytic converter **138** is greater than a predetermined threshold.

Referring now to FIG. **2**, the control module **140** is shown. The control module **140** may include a status determination module **200**, a mode determination module **210**, a closed-loop fuel control module **220**, a catalyst temperature protection module **230**, and an open-loop fuel control module **240**.

The status determination module **200** may communicate with the fuel injectors **118**, the ignition coils **119**, the spark plugs **120**, and/or the ignition fuses **122**, **124**. The status determination module **200** may determine when one of the fuel injectors **118**, the ignition coils **119**, the spark plugs **120**, and/or the ignition fuses **122**, **124** is in a failure state. For example only, the failure state for one of the fuel injectors **118** may correspond to a clogged injector line or an open-circuit. Additionally, for example only, the failure state for one of the ignition coils **119** and/or the spark plugs **120** may correspond to an open-circuit. Furthermore, for example only, the failure state for one of the ignition fuses **122**, **124** may correspond to a blown fuse.

The mode determination module **210** may receive the statuses of the fuel injectors **118**, the ignition coils **119**, the spark plugs **120**, and the ignition fuses **122**, **124**. The mode determination module **210** may determine a fuel control mode based on the received statuses of the fuel injectors **118**, the ignition coils **119**, the spark plugs **120**, and/or the ignition fuses **122**, **124**. More specifically, the mode determination module **210** may enable one of the closed-loop fuel control module **220** and the open-loop fuel control module **240** based on the received statuses.

The catalyst temperature protection module **230** may communicate with both the closed-loop fuel control module **220** and the open-loop fuel control module **240**. The catalyst temperature protection module **230** may be activated by the catalyst temperature T_{CAT}. In other words, for example, when the catalyst temperature T_{CAT} is greater than a predetermined temperature threshold the catalyst temperature protection module **230** may command the closed-loop fuel control module **220** or the open-loop fuel control module **240** to enrich the A/F ratio to prevent overheating (i.e. reduce temperature) of the catalytic converter **138**.

For example only, the mode determination module **210** may enable the closed-loop fuel control module **220** when none of the fuel injectors **118**, the ignition coils **119**, the spark plugs **120**, and the ignition fuses **122**, **124** are in a failure state. In other words, the closed-loop fuel control module **220** (i.e. closed-loop fuel control mode) may be a default mode.

The closed-loop fuel control module **220** receives the feedback signals from oxygen sensors **132**, **134** in the exhaust stream. The closed-loop fuel control module **220** may generate fuel injector (FI) control signals based on the feedback signals from oxygen sensors **132**, **134** and a predetermined A/F ratio. For example only, the predetermined A/F ratio may be 14.7:1 (i.e. stoichiometric). Additionally, for example only, the closed-loop fuel control module **220** may increase fuel injection (i.e. enrich the A/F ratio) when oxygen levels are higher than a predetermined threshold. However, as previously mentioned, the catalyst temperature protection module **230** may command the closed-loop fuel control module **220** to operate with an enriched A/F ratio when the catalyst temperature T_{CAT} is greater than the predetermined threshold. For example only, the catalyst temperature protection module **230** may command a richer A/F ratio than is currently being commanded to cool the temperature of the catalyst T_{CAT} in the catalytic converter **138**.

Alternatively, for example only, the mode determination module **210** may enable the open-loop fuel control module **240** when one of the fuel injectors **118**, the ignition coils **119**, the spark plugs **120**, and the ignition fuses **122**, **124** is in the failure state. However, different A/F ratios may be commanded based on which of the fuel injectors **118**, the ignition coils **119**, the spark plugs **120**, and the ignition fuses **122**, **124** are in the failure state.

First, the open-loop fuel control module **240** may command a first A/F ratio when one of the ignition fuses **122**, **124** is in the failure state. The open-loop fuel control module **240** may also disable the fuel injectors **118** corresponding to the one of the cylinder banks **106**, **108** that includes the failed ignition fuse. In other words, the open-loop fuel control module **240** may generate fuel injector (FI) control signals based on the first A/F ratio for the fuel injectors **118** corresponding to the one of the cylinder banks **106**, **108** without the failed ignition fuse. For example only, the first A/F ratio may be 14.7:1 (i.e. stoichiometric). Alternatively, for example only, the first A/F ratio may be based on engine speed **150** and/or driver input **160** via accelerator pedal position. In other words, the first A/F ratio may be based on achieving power and/or emissions requirements using only one of the cylinder banks **106**, **108** and thus only half of the cylinders **104**.

Second, the open-loop fuel control module **240** may command a second A/F ratio when one of the ignition coils **119** and the spark plugs **120** is in the failure state. More specifically, the open-loop fuel control module **240** may generate FI control signals based on the second A/F ratio. For example only, the second A/F ratio may be richer than stoichiometric (e.g. less than 14.7:1) and may be a function of a number of failed ignition coils **119** or failed spark plugs **120**.

Third, the open-loop fuel control module **240** may command a third A/F ratio when one of the fuel injectors **118** is in the failure state. The open-loop fuel control module **240** may also disable the fuel injector **118** that is in the failure state. For example, disabling the fuel injector **118** that is in the failure state may prevent fuel from being injected by the fuel injector **118** due to a short or an open-circuit.

In other words, the open-loop fuel control module **240** may generate FI control signals based on the third A/F ratio for the fuel injectors **118** that are not in the failure state. For example only, the third A/F ratio may be 14.7:1 (i.e. stoichiometric). Alternatively, for example only, the third A/F ratio may be a function of a number of failed fuel injectors **118**.

Referring now to FIG. **3**, a graph illustrating temperature of the catalytic converter **138** and A/F equivalence ratio (EQR) when one of the fuel injectors **118** is in the failure state and when one of the ignition coils **119** or spark plugs **120** is in the failure state. For example, the A/F EQR may be a stoichiometric A/F ratio (14.7:1) divided by the current A/F ratio.

When one of the fuel injectors **118** is in the failure state, decreasing the A/F EQR to near 1.00 (i.e. A/F ratio near 14.7:1) may decrease temperature of the catalytic converter **138**. For example, the A/F EQR near 1.00 (A/F ratio near 14.7:1) may correspond to the third A/F ratio (i.e. stoichiometric). Additionally, the A/F EQR near 1.00 may correspond to the first A/F ratio (i.e. ignition fuse failure).

Conversely, when one of the ignition coils **119** or the spark plugs **120** is in the failure state, increasing the A/F EQR above 1.00 (i.e. decreasing A/F ratio below 14.7:1) may decrease temperature of the catalytic converter **138**. For example, the A/F EQR above 1.00 (e.g. 1.45, or an A/F ratio of 10.1:1) may correspond to the second A/F ratio (i.e. rich).

Therefore, in general, leaning the A/F mixture (towards stoichiometric) when one of the fuel injectors **118** is in the failure state and enriching the A/F mixture (above stoichiometric) when one of the ignition coils **119** or the spark plugs **120** is in the failure state may increase performance and/or prevent damage to the catalytic converter **138**. Additionally, in general, leaning the A/F mixture (towards stoichiometric) when one of the ignition fuses **122**, **124** is in the failure state may increase performance and/or prevent damage to the catalytic converter **138**.

More specifically, the excessive temperatures of the catalytic converter **138** may decrease exhaust catalyzation efficiency and/or damage the catalytic converter **138**. For example only, when the catalytic converter is heated to a temperature over 850° C., a catalyst in the catalytic converter **138** may be aged or damaged irreversibly.

Referring now to FIG. **4**, a flow diagram illustrating a method of operating the engine system **100** (i.e. determining fuel control modes) begins in step **300**. In step **302**, the control module **140** determines whether one of the ignition fuses **122**, **124** is in the failure state. If true, control may proceed to step **304**. If false, control may proceed to step **306**.

In step **304**, the control module **140** disables fuel injectors **118** corresponding to the one of the cylinder banks **106**, **108** that includes the failed ignition fuse. Additionally, the control module **140** enables open-loop fuel control mode with the first A/F ratio (i.e. stoichiometric). Control may then return to step **302**.

In step **306**, the control module **140** determines whether one of the fuel injectors **118** is in the failure state. If true, control may proceed to step **308**. If false, control may proceed to step **310**. In step **308**, the control module **140** may disable the fuel injector that is in the failure state and then may enable open-loop fuel control mode with the third A/F ratio (i.e. stoichiometric). Control may then return to step **302**.

In step **310**, the control module **140** determines whether one of the ignition coils **119** or the spark plugs **120** is in the failure state. If true, control may proceed to step **312**. If false, control may proceed to step **314**. In step **312**, the control module **140** may enable open-loop fuel control mode with the second A/F ratio (i.e. rich). Control may then return to step **302**.

In step **314**, the control module **140** may enable closed-loop fuel control mode (i.e. default mode), and control may return to step **302**.

Those skilled in the art can now appreciate from the foregoing description that the broad teachings of the disclosure can be implemented in a variety of forms. Therefore, while this disclosure includes particular examples, the true scope of the disclosure should not be so limited since other modifications will become apparent to the skilled practitioner upon a study of the drawings, the specification, and the following claims.

What is claimed is:

1. An engine system, comprising:

a status determination module that determines whether a first ignition fuse is in a failure state; and

an open-loop fuel control module that disables a first plurality of fuel injectors and actuates a second plurality of fuel injectors based on a first air/fuel (A/F) ratio when the first ignition fuse is in the failure state,

wherein the first ignition fuse and the first plurality of fuel injectors correspond to a first cylinder bank, and wherein a second ignition fuse and the second plurality of fuel injectors correspond to a second cylinder bank.

2. The engine system of claim **1**, wherein the first A/F ratio is one of stoichiometric and based on at least one of an engine load, an engine speed, and an engine temperature.

3. The engine system of claim **1**, wherein the status determination module determines when one a first plurality of ignition coils, a first plurality of spark plugs, a second plurality of ignition coils, and a second plurality of spark plugs is in the failure state,

wherein the first plurality of ignition coils and the first plurality of spark plugs correspond to the first cylinder bank, and wherein the second plurality of ignition coils and the second plurality of spark plugs correspond to the second cylinder bank.

4. The engine system of claim **3**, wherein the open-loop fuel control module actuates the first and second pluralities of fuel injectors based on a second A/F ratio when one of the first and second pluralities of ignition coils and the first and second pluralities of spark plugs is in the failure state.

5. The engine system of claim **4**, wherein the second A/F ratio is one of richer than stoichiometric and based on a number of the first and second pluralities of ignition coils and the first and second pluralities of spark plugs that are in the failure state.

6. The engine system of claim **1**, wherein the status determination module determines whether one of the first and second pluralities of fuel injectors is in the failure state.

7. The engine system of claim **6**, wherein the open-loop fuel control module actuates the first and second pluralities of fuel injectors based on a third A/F ratio when one of first and second pluralities of fuel injectors is in the failure state.

8. The engine system of claim **7**, wherein the third A/F ratio is one of stoichiometric and based on a number of the first and second pluralities of fuel injectors that are in the failure state.

9. The engine system of claim **3**, further comprising:

a closed-loop fuel control module that actuates the first and second pluralities of fuel injectors based on a predetermined A/F ratio and an oxygen level in an exhaust stream when none of the first and second ignition coils, the first and second pluralities of fuel injectors, the first and second pluralities of ignition coils, and the first and second pluralities of spark plugs are in the failure state.

10. A method, comprising:

determining whether a first ignition fuse is in a failure state; and

disabling a first plurality of fuel injectors and actuating a second plurality of fuel injectors based on a first air/fuel (A/F) ratio when the first ignition fuse is in the failure state,

wherein the first ignition fuse and the first plurality of fuel injectors correspond to a first cylinder bank, and wherein a second ignition fuse and the second plurality of fuel injectors correspond to a second cylinder bank.

11. The method of claim **10**, wherein the first A/F ratio is one of stoichiometric and based on at least one of an engine load, an engine speed, and an engine temperature.

12. The method of claim **10**, further comprising:

determining when one a first plurality of ignition coils, a first plurality of spark plugs, a second plurality of ignition coils, and a second plurality of spark plugs is in the failure state,

wherein the first plurality of ignition coils and the first plurality of spark plugs correspond to the first cylinder bank, and wherein the second plurality of ignition coils and the second plurality of spark plugs correspond to the second cylinder bank.

13. The method of claim **12**, further comprising:

actuating the first and second pluralities of fuel injectors based on a second A/F ratio when one of the first and second pluralities of ignition coils and the first and second pluralities of spark plugs is in the failure state.

14. The method of claim **13**, wherein the second A/F ratio is one of richer than stoichiometric and based on a number of the first and second pluralities of ignition coils and the first and second pluralities of spark plugs that are in the failure state.

15. The method of claim **10**, further comprising:

determining whether one of the first and second pluralities of fuel injectors is in the failure state.

16. The method of claim **15**, further comprising:

actuating the first and second pluralities of fuel injectors based on a third A/F ratio when one of first and second pluralities of fuel injectors is in the failure state.

17. The method of claim **16**, wherein the third A/F ratio is one of stoichiometric and based on a number of the first and second pluralities of fuel injectors that are in the failure state.

18. The method of claim **12**, further comprising:

actuating the first and second pluralities of fuel injectors based on a predetermined A/F ratio and an oxygen level in an exhaust stream when none of the first and second ignition coils, the first and second pluralities of fuel injectors, the first and second pluralities of ignition coils, and the first and second pluralities of spark plugs are in the failure state.

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